



# Design & Fabrication Of Tilting Vehicle

**UDRRE SURESH**

B.Tech Student, Dept of Mechanical,  
Aurora Scientific Technological & Research Academy,  
Hyderabad, Telangana, India

**GOULIKAR HEMANTHKUMAR**

B.Tech Student, Dept of Mechanical,  
Aurora Scientific Technological & Research Academy,  
Hyderabad, Telangana, India

**MOHAMMED JUNAID PASHA**

B.Tech Student, Dept of Mechanical,  
Aurora Scientific Technological & Research Academy,  
Hyderabad, Telangana, India

**M.NIRISH**

Assistant Professor,  
Aurora Scientific Technological & Research Academy,  
Hyderabad, Telangana, India

**Abstract:** This project report includes information regarding “TILTING MECHANISM” of a four wheel vehicle. The main objective of the project is to design and fabricate a four wheel tilting vehicle. The vehicle consists of the independent suspension system. The design of the vehicle is to be obtained by setting up parameters such as track width, vehicle length and ride height.

By discussing and calculating the basic dimensions of the vehicle the main frame was designed in Solid Works and the frame was analyzed using Solid Works-Simulation and after the design was finished according to several attempts. The manufacturing part is to be done in a workshop where all tools needed are available at exposal.

The report also determines the suspension profile needed for the mechanism to avoid the load factors. It also contains the profile of wishbones used in the front suspension part of the types of joints used for the free movement of the wheels during bumps and uneven roads, upgrade in the design of knuckle hubs, tie rod linkages.

The operation carried out in the process of fabricating the whole vehicle is included in the report.

## I. TILTING VEHICLE

A Tilting vehicle is the one who's body and/or wheels tilt in the direction of the turn. It is most common leaning multi wheeler type. Such vehicles can corner safely and comfortably despite having a narrow track. Therefore they are, unlike single-track vehicles such as two-wheeled bicycles and motorcycles, suitable for a year-round utilization time.

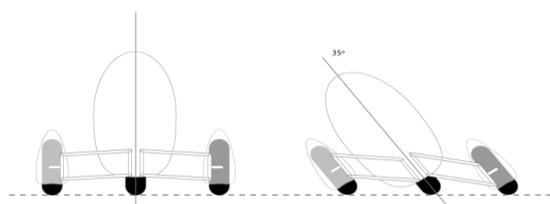


Figure showing steady & leaned Vehicle ( $L-35^0$ )

## II. FACTORS CONSIDERED FOR DESIGNING AND FABRICATING A LEANING VEHICLE

- Roll over stability
- Ride height
- Centre of gravity
- Ground clearance
- Cornering forces
- Banking angle
- Lean angle
- Roll centre
- Steer characteristics
- Braking

- Vehicle dynamic
- Toe in & Toe out
- Camber angle
- Turning radius
- Pendulum mechanism

## III. SUSPENSION& STEERING

### SUSPENSION

- Suspension is the system of tires, tire air, springs, shock absorbers and linkages that connects a vehicle to its wheels and allows relative motion between the two. Suspension systems serve a dual purpose — contributing to the vehicle's road holding/handling and braking for good active safety and driving pleasure, and keeping vehicle occupants comfortable and a ride quality reasonably well isolated from road noise, bumps, vibrations, etc. These goals are generally at odds, so the tuning of suspensions involves finding the right compromise.

### TERMS RELATED TO SUSPENSION

#### a. WEIGHT TRANSFER:

- Weight transfer during cornering, acceleration or braking is usually calculated per individual wheel and compared with the static weights for the same wheels.
- The total amount of weight transfer is only affected by four factors: the distance between wheel centers (wheelbase in the case of braking,

or track width in the case of cornering) the height of the center of gravity, the mass of the vehicle, and the amount of acceleration experienced.

#### **b. UNSPRUNG WEIGHT TRANSFER:**

Unsprung weight transfer is calculated based on the weight of the vehicle's components that are not supported by the springs. This includes tires, wheels, brakes, spindles, half the control arm's weight and other components. These components are then (for calculation purposes) assumed to be connected to a vehicle with zero sprung weight. They are then put through the same dynamic loads. The weight transfer for cornering in the front would be equal to the total unsprung front weight times the G-Force times the front unsprung center of gravity height divided by the front track width. The same is true for the rear.

#### **c. SPRUNG WEIGHT TRANSFER:**

Sprung weight transfer is the weight transferred by only the weight of the vehicle resting on the springs, not the total vehicle weight. Calculating this requires knowing the vehicle's sprung weight (total weight less the unsprung weight), the front and rear roll center heights and the sprung center of gravity height (used to calculate the roll moment arm length). Calculating the front and rear sprung weight transfer will also require knowing the roll couple percentage

#### **STEERING:**

A Motorcycle handlebar is a tubular component of a motorcycle's steering mechanism. Handlebars provide a mounting place for controls such as brake, throttle, clutch, horn, light switch and rear view mirrors; and they may support part of the rider's weight. Even when a handlebar is a single piece it is usually referred to in the plural as handlebars.

#### **SIZES:**

There are several size parameters that describe most motorcycle handlebars.

- Width from grip to grip may vary from 30.5 to 37 inches (770 to 940 mm).
- May rise above triple clamp up to 24 in (610 mm) or more, called ape hangers when very high, or may drop a few inches below, called clubman bars.
- Pullback, the distance grips are behind their mounting location, may vary from 4.25 to 17 in (108 to 432 mm).
- Diameters vary; commonly  $\frac{7}{8}$ , 1, and  $1\frac{1}{4}$  in (22, 25, and 32 mm), though oversized bars of  $1\frac{1}{4}$ ,  $1\frac{1}{2}$ , and  $1\frac{3}{4}$  in (32, 38, and 44 mm) may reduce to 1 in (25 mm) at the grips so standard controls may be mounted.

#### **TIE ROD:**



**Figure: Tie rods**

#### **IV. VEHICLE SELECTION**

- Design attributes
- Handling & Stability
- Load
- Efficiency
- Easily access able
- Performance
- Vehicle Configurations
- Economical
- Market Value, etc.

Thus based on this considerations the Vehicle opted/selected for this project is

**“HERO HONDA CD 100SS”**



**Figure: HERO HONDA CD 100SS**

#### **TECHNICAL SPECIFICATIONS**

##### **a) ENGINE:**

Engine displacement	97.2cc
Engine type	Air coole.4 stroke
Number of cylinders	1
Valves per cylinder	2
Max power	7.3@8000rpm
Max torque	N/A
Bore x stroke	N/A
Fuel type	Petrol
Starter	Kick

**Table : Engine specification**

##### **b) TRANSMISSION:**

Transmission type	Manual
Number of speed gears	4
Final drive (rear wheel)	Chain

**Table : Transmission**

**c) WHEELS & TIRES:**

Front tire (full spec)	2.75x18
Rear tire (full spec)	3.00x18

**Table : wheel& tires**

**d) BRAKES:**

Front brake type	110mm drum
Rear brake type	110mm drum

**Table :brakes**

**e) SUSPENSION:**

Suspension front	Telescopic hydraulic fork
Suspension rear	Spring loaded hydraulic with both side action

**Table :suspension**

**f) DIMENSIONS:**

Overall length	1960mm
Overall width	720mm
Overall height	1050mm
Wheel base	1225mm
Ground clearance	165mm
Kerb weight	112kg
Fuel capacity	10.1liters

**Table : overall dimensions**

**V. VEHICLE DIS-ASSEMBLE**

- Handle Disassembly
- Front Shocks
- Fuel Tank
- Electricals
- Seat
- Mud Guards
- Air Filters
- Lock Kit
- Brakes
- Wheel disassembly
- Foot Rest disassembly
- Tool Kit disassembly

Thus after the disassembly of vehicle the further process is material selection & Fabrication of vehical.

**Wheel removal:**

The wheels are a major part of the vehicle they transmit the motion of the vehicle. In order to

disassemble the whole vehicle the wheels are removed so that it becomes stationary.

**VI. DESGIN**

Designing often necessitates considering the aesthetic, functional, economic and sociopolitical dimensions of both the design object and design process. It may involve considerable research, thought, modeling, interactive adjustment, and re-design. Meanwhile, diverse kinds of objects may be designed, including clothing, graphical user interfaces, skyscrapers, corporate identities, business processes and even methods of designing.

Thus "design" may be a substantive referring to a categorical abstraction of a created thing or things (the design of something), or a verb for the process of creation, as is made clear by grammatical context.

**METHODS OF DESIGNING:**

Design method is a broad area that focuses on:

- **Exploring:** possibilities and constraints by focusing critical thinking skills to research and define problem spaces for existing products or services—or the creation of new categories; (see also Brainstorming)
- **Redefining:** the specifications of design solutions which can lead to better guidelines for traditional design activities (graphic, industrial, architectural, etc.);
- **Managing:** the process of exploring, defining, creating artifacts continually over time
- **Prototyping:** possible scenarios, or solutions that incrementally or significantly improve the inherited situation
- **Trend spotting:** understanding the trend process.

**DESIGN NORMS:**

**Cultural Appropriateness:**It is an innovative approach to solving issues associated with driving. Our culture respects innovation and welcomes the independence shown by differentiating our product.

**Integrity:** As most race vehicles do, our project fully integrates form and function into a performance-driven machine with aesthetics not burdened by but rather defined by its purpose.

**Caring:** We seek to provide a safe, reliable product which will improve user comfort.

**Transparency:**Our suspension will provide clear and predictable feedback for the driver. It will be responsive, allowing the driver to feel the cornering conditions of the vehicle and make appropriate adjustments as needed.

**DESIGN CHALLENGES:**

**Simplicity:** The product or any object which is to be designed should be much simpler as it should be understandable by everyone. The complexity in design makes the production more complex.

The frame, secondary and primary suspension arms were also simplified in order to aid fabrication. Again, the original design called for bent round tubing welded at complicated angles.

**Adjustability:** The prototype was designed with certain adjustable features to compensate for uncertainty in the design and variations in testing conditions (e.g. operator weight). This was achieved through adjustable tie-rods for the primary suspension spread, the lean mechanism and the steering linkage lengths.

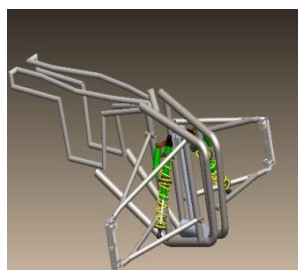
#### VEHICLE DESIGN CONSIDERATIONS:

**Design Objective:** The first thing a manufacturer must consider is the specific job the automobile should perform. Based on the requirements, different types of automobiles have been designed-such as, trucks, buses, cars, trailers, racing cars etc. Design Parameters. The designer of an automobile must consider the maximum required acceleration, speed, economy, load to be carried, ride and handling characteristics, size etc., that are expected from the vehicle. The maximum limits of these features are called the design parameters. A finished automobile is a blend of all these components, one feature traded off against another, to produce the final product.

**Durability:** Each part of the vehicle has a specific design life which takes into account its operating load, speed, temperature, lubrication etc. Life of all the components together decides. The time period the vehicle should operate before major service is required

**Cost:** One of the best selling points is a low price. Therefore, one of the major design objectives is to lower the price without compromising the design parameters. In some cases, a large reduction in costs can be accomplished with only a slight compromise in a design objective. The cost reduction is also possible by changing the manufacturing method or by

#### SOLID WORKS:



*Figure : Design and assembly of frame*

#### INDIVIDUAL COMPONENT DESIGN:

Frame

Arms

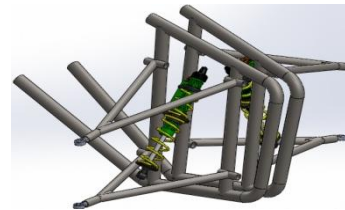
Mechanism

Steer linkage

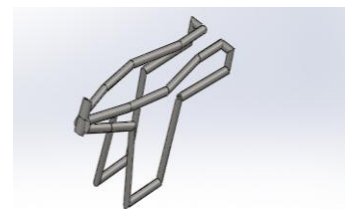
Tie rods

Hubs

ASSEMBLY



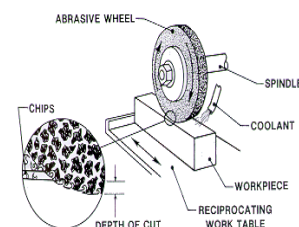
*Figure : Frame*



*Figure : Arm and mechanism*

#### MATERIAL SELECTION:

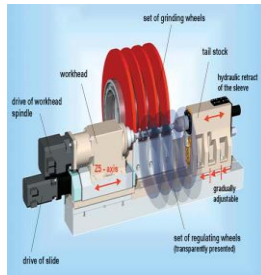
The choice of materials for a vehicle is the first and foremost important factor for automotive design. There is a variety of materials that can be used in automotive body and chassis, but the purpose of design is the main challenge here. The most important criteria that a material should meet are light weight, safety, life cycle considerations, etc. Some of these criteria are the result of legislation and regulations. However, some of these criteria may be conflicting and therefore the optimization comes into business here.



*Figure: Grinding wheel*

#### EQUIPMENT:





**Figure : Grinding operation**



**Figure : A-Arms**

## **FABRICATION OF INDIVIDUAL COMPONENTS:**

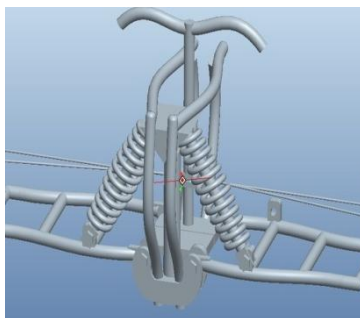
### **a. FRAME:**



**Figure : Frame**

### **b. SUSPENSIONS:**

Suspension fabrication began with welding sleeves (round tubing) to the arms (square tubing). Because warping quickly proved to be a major issue, we built a custom jig to hold the sleeves perpendicular to the arms and at the correct position. Warping was still present but was deemed acceptable. In some cases, the arms had to be heated and bent to correct for warping.



**Figure : Suspensions**

### **c. ARMS:**

### **HUB/UPRIGHT:**



**Figure : Hub/up right**

### **d. TIE ROD AND STEERING LINKAGE:**



**Figure :Tie rod and steering linkage**



**Figure : Pendulum mechanism**

## **VII. INSPECTION & TESTING**

The problem\defects found after the first test are due to:

- Wheel Alignment
- Variation in Arms length

- Hub design
- Dampers displacement

The problems which occurred after first testing are fixed by making some modifications and are reassembled and again the testing of vehicle is done for finding the defects. Hence, after the second test the problems occurred at first phase of testing are not found. The minor problems which are found after the second stage of testing are overcome by reworking.



**Figure : Before hub**



**Figure: After hub**



**Figure : After testing**

## VIII. CONCLUSION

It can be seen from the above result that, our objective to increase the threshold velocity of a narrow vehicle in a curve has been successful. The design of the car and tilting mechanism worked flawlessly in simulation as well. The prototype to demonstrate tilting is also working successfully, all these facts point to the completion of our objective in high esteem.

## IX. REFERENCES

- [1]. M. Barker. Chassis Design and Dynamics of a Tilting Three Wheeled Vehicle. PhD thesis, University of Bath, Bath, UK, 2006.
- [2]. R. Hibbard and D. Karnopp. "Methods of Controlling the Lean Angle of Tilting Vehicles". ASME, Dynamic Systems and Control Division (Publication) DSC,

Transportation Systems, 52:311–320, 1993.

- [3]. R. Hibbard and D. Karnopp. "The Dynamics of Small, Relatively Tall and Narrow Tilting Ground Vehicles". ASME, Dynamic Systems and Control Division (Publication) DSC, Transportation Systems, 52:397–417, 1993.
- [4]. R. Gohl, R. Rajamani, L. Alexander, and P. Starr. "The Development of Tilt-Controlled Narrow Ground Vehicles". In Proceedings of the American Control Conference, 2002.
- [5]. H. B. Pacejka. "Tyre and Vehicle Dynamics". Butterworth-Heinemann, 2002.
- [6]. W. F. Milliken and D. L. Milliken. "Race Car Vehicle Dynamics". SAE, 1995.
- [7]. V. Cossalter. "Motorcycle Dynamics 2nd Edition". LuLu (Self-Publishing), 2006.
- [8]. A. Wiedele and M. Schmieder. "Research on the Power Transfer of Motorcycle Tires on Real Road Surfaces". In Proceedings of the 18th FISITA Congress, 1990.

## AUTHOR'S PROFILE



Mr. UDRRE SURESH S/O UDRRE GANGADHAR was born in Hyderabad, India in 1994 December 24. He received the B.Tech degree in Mechanical Engineering from Aurora's Scientific Technological and Research Academy, Hyderabad, JNTUH; India in 2016 and He also attended no. of workshops and internship in overall in Hyderabad.

Member of "Society of Automobile Engineers" and organized many technical events at college level (**Membership Id: 7150422294**).

His current planning to study masters in abroad and interested in INDUSTRIAL MANAGEMENT and MANUFACTURING INDUSTRY.



Mr. MOHAMMED JUNAID PASHA S/O MOHAMMED KHADEER PASHA was born in Hyderabad, India in 1995 AUGUST 22. He received the B.Tech degree in Mechanical Engineering from Aurora's Scientific Technological and Research Academy, Hyderabad, JNTUH; India in 2016 and He also attended no. of workshops and internship in overall in Hyderabad.

Member of "Society of Automobile Engineers" and organized many technical events at college level

(**Membership Id: 7150422259**).

Team Captain and Lead designer of SAE BAJA College team

His current planning to study masters in Germany and interested in MANUFACTURING INDUSTRY and AUTOMOBILE INDUSTRY.



Mr. GOULIKAR  
HEMANTHKUMAR S/O  
GOULIKAR ASHOKA KUMAR  
was born in Hyderabad, India in  
1995 JULY 22. He received the  
B.Tech degree in Mechanical

Engineering from Aurora's Scientific Technological and Research Academy, Hyderabad, JNTUH; India in 2016 and He also attended no. of workshops and internship in overall in Hyderabad.

His current planning to study masters in abroad and interested in PRODUCTION TECHNOLOGY and MANUFACTURING INDUSTRY.



M.NIRISH (M') was born in india in  
1991. He received the B.Tech in  
mechanical engineering and M.Tech  
in Machine design from the  
Jawaharlal Nehru University of  
Hyderabad in 2012 and 2014,

respectively. Since then, He was worked as an assistant professor of department of Mechanical engineering Aurora Scientific Technology Research and Academy, Hyderabad, India From 2012-2015 .He joined the department of Mechanical engineering, Nishitha college of engineering and Technology, as an Asst. Prof.